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**Tumey et al.**

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## (54) ANIMATED TOY UTILIZING ARTIFICIAL INTELLIGENCE AND FINGERPRINT VERIFICATION

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(51) **Int. Cl.**[7] .......................... **G06K 9/00**; A63H 29/22

(52) **U.S. Cl.** ........................ **382/124**; 434/155; 446/484

(58) **Field of Search** ................................ 382/124–127, 382/115–123; 446/484; 434/155

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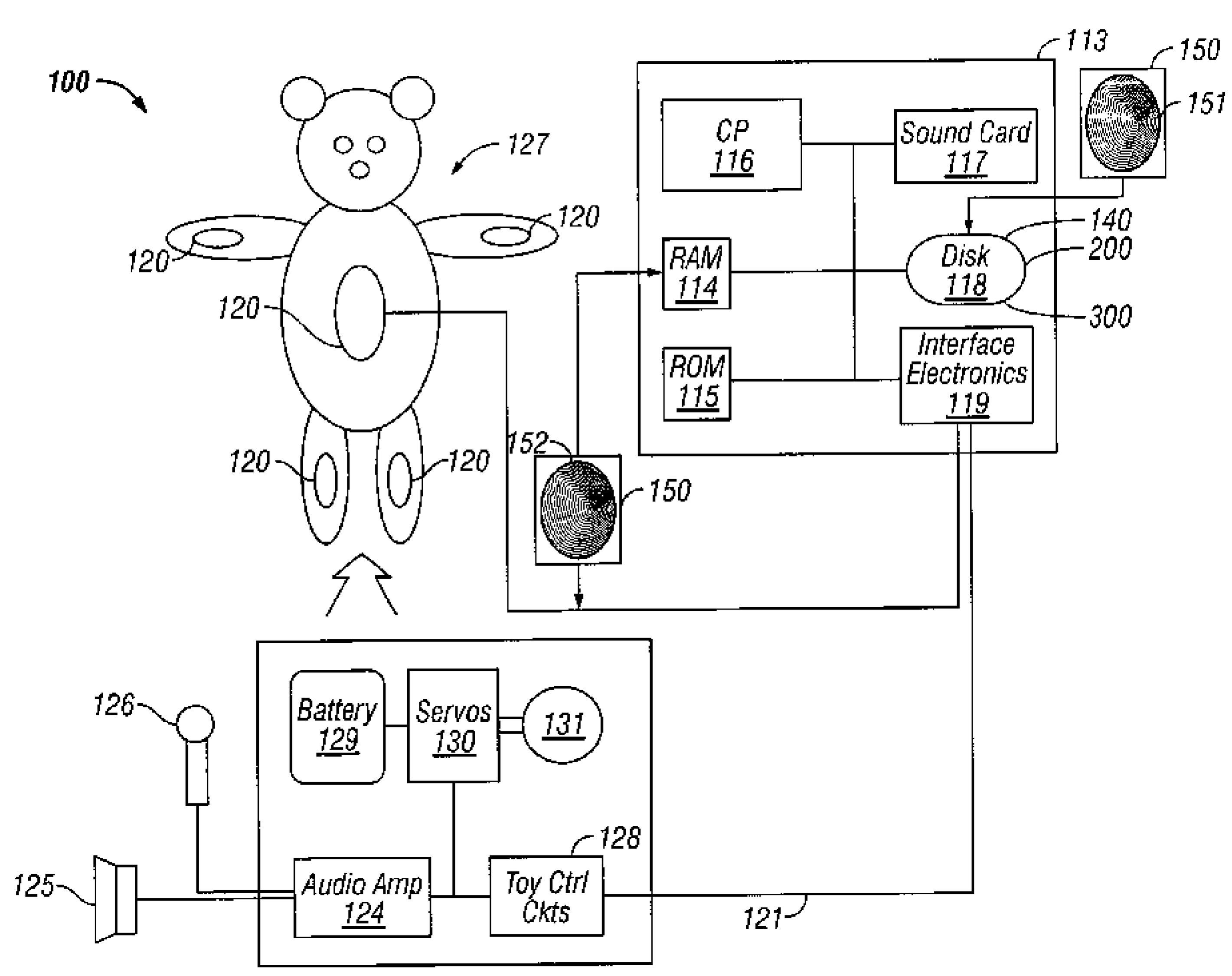
(57) **ABSTRACT**

An articulated and animated toy capable of recognizing human users and interacting therewith which includes a computer-based device having stored thereon encoded first human fingerprint data, a fingerprint sensor for acquiring data representative of a second human fingerprint, and software resident within said computer-based device for fingerprint verification, which includes minutiae analysis, neural networks, or another equivalent algorithm for comparing said first human fingerprint data with said second human fingerprint data and producing an output signal therefrom for use in identifying said human users. The apparatus can further include software for recognizing speech, generating speech and controlling animation of the articulated toy. In addition, said computer-based device is capable of learning and storing information pertaining to each of said human users such as name, age, sex, favorite color, etc., and to interact with each of said human users on an individual basis, providing entertainment tailored specifically to each of said human users. In addition, the apparatus can control access to the Internet via integrated web browser software and thus provide protection, especially for young children, from inappropriate web site content.

**1 Claim, 3 Drawing Sheets**



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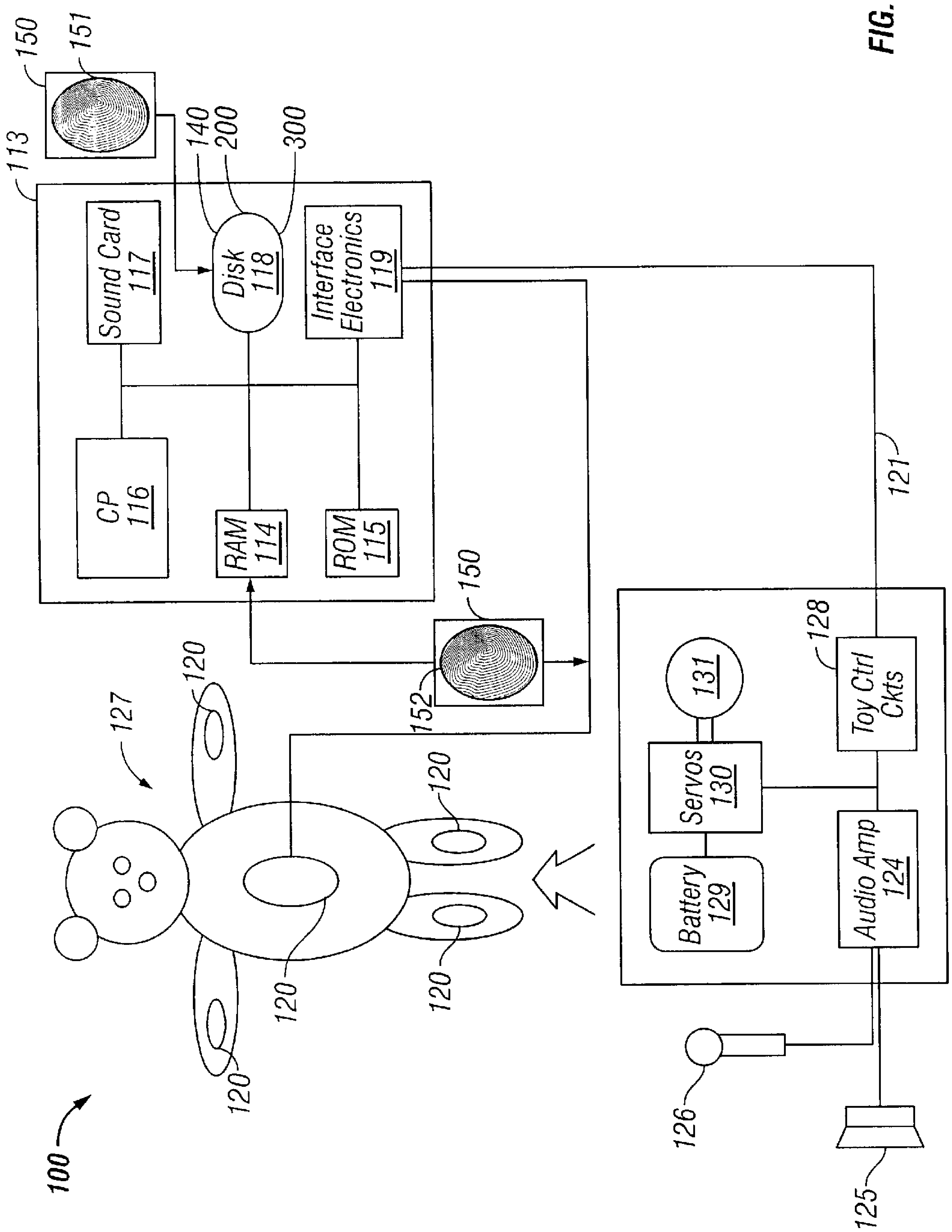
100
113
150
151
140
200
300
Sound Card 117
Disk 118
Interface Electronics 119
CP 116
RAM 114
ROM 115
150
152
121
127
120
120
120
120
120
120
128
131
Servos 130
Toy Ctrl Ckts
Battery 129
Audio Amp 124
126
125

FIG. 1

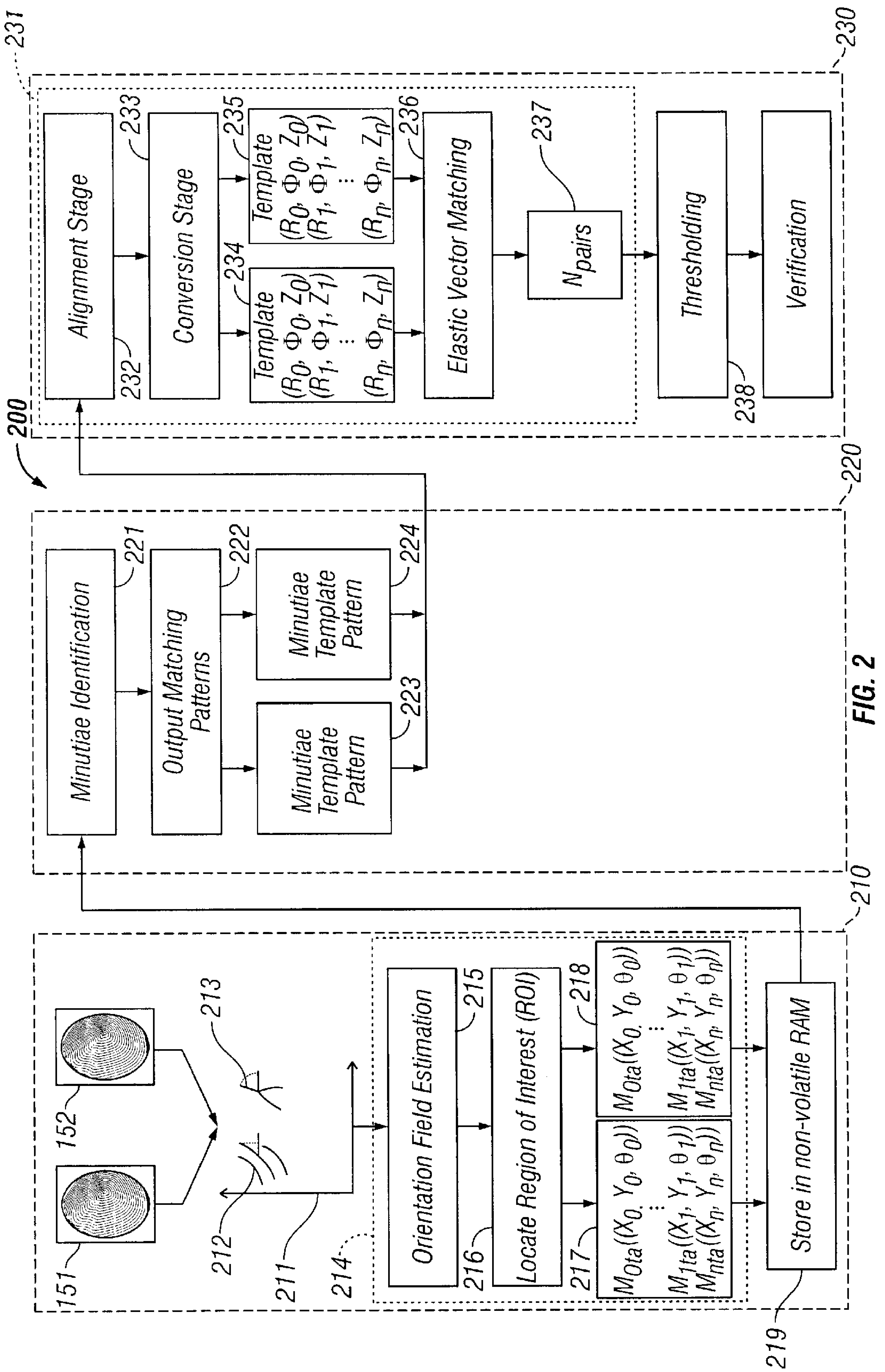
200
Alignment Stage
Conversion Stage
Template $(R_0, \Phi_0, Z_0)$ $(R_1, \Phi_1, Z_1)$ ⋮ $(R_n, \Phi_n, Z_n)$
Template $(R_0, \Phi_0, Z_0)$ $(R_1, \Phi_1, Z_1)$ ⋮ $(R_n, \Phi_n, Z_n)$
Elastic Vector Matching
$N_{pairs}$
Thresholding
Verification
Minutiae Identification
Output Matching Patterns
Minutiae Template Pattern
Minutiae Template Pattern
Orientation Field Estimation
Locate Region of Interest (ROI)
$M_{0ta}(X_0, Y_0, \theta_0))$ $M_{1ta}(X_1, Y_1, \theta_1))$ ⋮ $M_{nta}(X_n, Y_n, \theta_n))$
$M_{0ta}(X_0, Y_0, \theta_0))$ $M_{1ta}(X_1, Y_1, \theta_1))$ ⋮ $M_{nta}(X_n, Y_n, \theta_n))$
Store in non-volatile RAM
151 152 211 212 213 214 215 216 217 218 219 210 220 221 222 223 224 230 231 232 233 234 235 236 237 238

FIG. 2

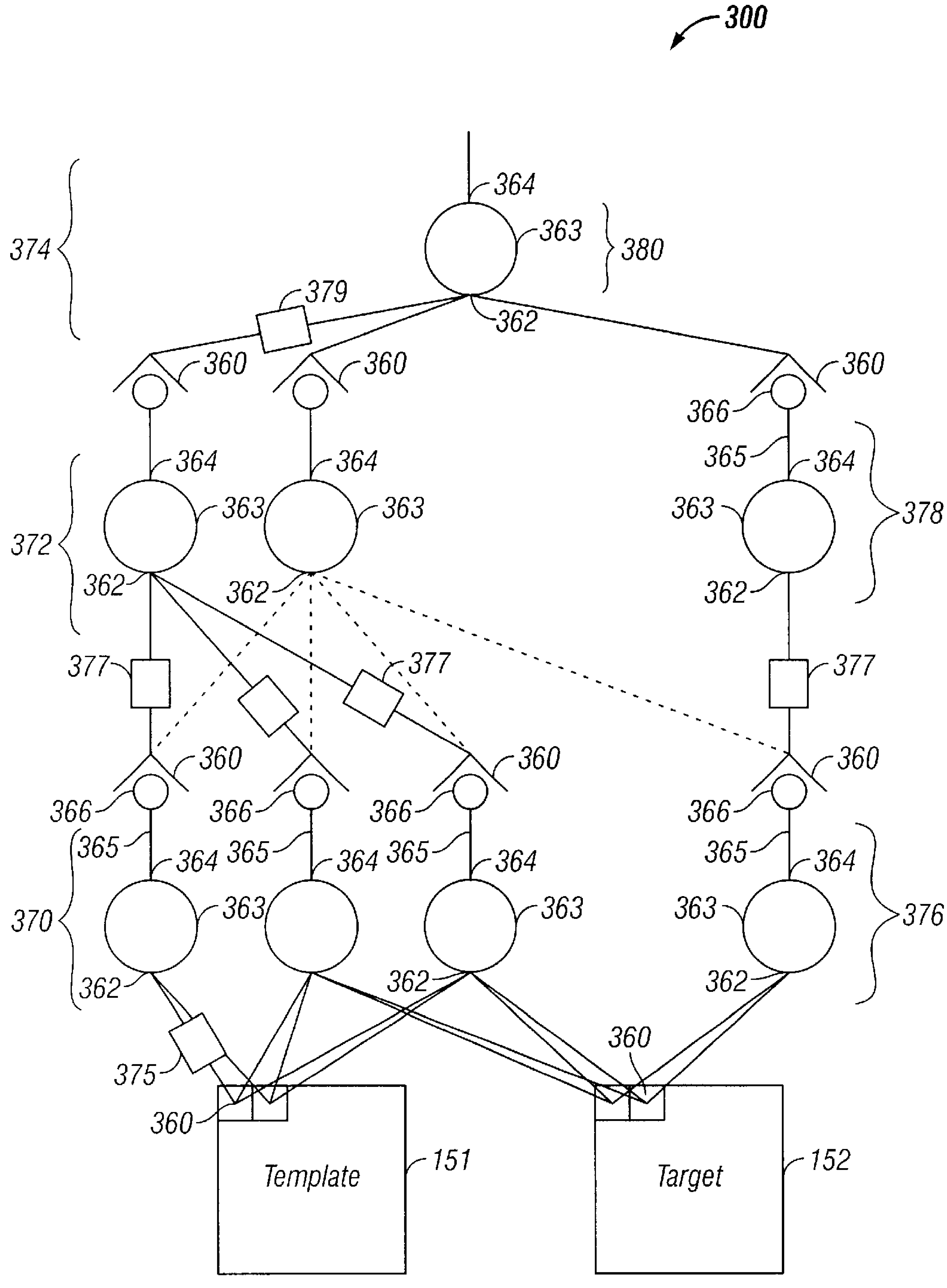
300
364
363
380
374
379
362
360
360
360
366
364
364
365
364
372
363
363
363
378
362
362
362
377
377
377
360
360
360
366
366
366
366
365
365
365
365
364
364
364
364
370
363
363
363
376
362
362
362
362
360
375
360
Template
151
Target
152

FIG. 3

# ANIMATED TOY UTILIZING ARTIFICIAL INTELLIGENCE AND FINGERPRINT VERIFICATION

## RELATED APPLICATION INFORMATION

This application is a continuation in part of co-pending and commonly assigned provisional application for letters patent serial No. 60/137,569 filed Jun. 4, 1999 entitled "ANIMATED TOY UTILIZING ARTIFICIAL INTELLIGENCE AND FRINGERPRINT VERIFICATION."

## FIELD OF THE INVENTION

The present invention is generally directed to an apparatus and method for integrating a fingerprint sensor and computer-based algorithm with an articulated and animated toy capable of recognizing a human user, and providing entertainment and interaction with said human user in response thereto. In addition, said computer-based toy can learn and store in resident memory, specific information about said human user and further access and recall said information for use in interacting with said human user, such as integrating personal information about said user into a story or game, or controlling access to the Internet after said user is identified. The former providing guidance and protection from inappropriate content, especially for young children.

## BACKGROUND OF THE INVENTION

There are a number of new articulated and animated toys capable of interacting with human users in a way which appears intelligent which are well known in the art and commercially available under such trademarks as Furby® from Tiger Electronics, Ltd., and Barney® from MicroSoft Inc. These toys are capable of understanding speech, speaking in a natural language and demonstrating limited animation such as mouth, eye and ear movements. In addition, prior to the development of these more sophisticated toys, which generally include an embedded microprocessor and computer-based algorithm, other predecessors such as that commonly known under the trademark Teddy Ruxpin™ from YES! Entertainment Corporation, are also capable of exhibiting semi-intelligent behavior through speech and animation. Teddy Ruxpin™, and other toys like it, utilize a tape mechanism to provide the sound and animation control. Without exception, to date, a toy has never been developed which is capable of recognizing the human user who is playing with the toy. The advantage of such capability is immediately obvious as it increases the sophistication and intelligence of a toy to levels heretofore unseen. A toy with the capability of recognizing its human user can learn specific information about said human user and interact individually with a number of said human user's by providing tailored entertainment. In addition, toys capable of recognizing an individual human user could control access to the Internet through integrated web browser software and thus provide protection, especially for young children, from inappropriate web site content.

There exists many methods for creating the semblance of intelligence in a toy or computer game. Toys with animated moving parts are commonplace and anyone of ordinary skill in the art will be familiar with several methods to fabricate quasi-intelligent articulated toys. Similarly there exists many methods for the biometric identification of humans which includes face recognition, voice recognition, iris scanning, retina imaging as well as fingerprint verification.

Iris and retina identification systems are considered "invasive", expensive and not practical for applications such as integrating with a toy where limited computer memory storage is available and manufacturing costs must be minimized. Voice recognition, which is not to be confused with speech recognition, is somewhat less invasive, however it is cost prohibitive and can require excessive memory storage space for the various voice "templates". In addition, identification processing delays can be excessive and unacceptable for many applications.



Fingerprint verification is a minimally invasive way to identify a human user. A fingerprint verification and identification system can be constructed in such a way that its operation is simple and natural for a human user. With recent advances in the performance of inexpensive single board computers and embedded microprocessors, it has become possible to implement a practical and cost effective fingerprint verification system for use in providing human user recognition for toys or computer games.

Although many inventors have offered approaches to verifying human fingerprints for recognizing human users, none have succeeded in producing a system that would be viable for use in an articulated and animated toy or computer game. Part of the reason for this lies in the severe constraints imposed on the sensor apparatus such as size and physical configuration. Another reason is that the complexity of the algorithms and the hardware necessary to implement them makes such a recognition system cost prohibitive for use with a toy.

The present invention overcomes these limitations by combining streamlined algorithms with advanced microprocessor architectures. The algorithms of the present invention have been optimized to run quickly on small inexpensive single board computers and embedded microprocessors.

## SUMMARY OF THE INVENTION

It is an object of the present invention to improve the apparatus and method for fingerprint verification of human users for use with articulated and animated toys or computer games.

It is another object of the present invention to improve the apparatus and method for creating the semblance of intelligence in an articulated and animated toy or computer game.

It is still another object of the present invention to improve the method for providing protection, especially for young children, from inappropriate Internet web site content.

Accordingly, one embodiment of the present invention is directed to an apparatus for an articulated and animated toy capable of recognizing human users and interacting therewith which includes a computer-based device having stored thereon encoded first human fingerprint data, a fingerprint sensor for acquiring data representative of a second human fingerprint, and software resident within said computer-based device for fingerprint verification, which includes minutiae analysis, neural networks, or another equivalent algorithm for comparing said first human fingerprint data with said second human fingerprint data and producing an output signal therefrom for use in identifying said human users. The apparatus can further include software for recognizing speech, generating speech and controlling animation of the articulated toy. In addition, said computer-based device is capable of learning and storing information pertaining to each of said human users such as name, age, sex, favorite color, etc., and to interact with each of said human users on an individual basis, providing entertainment tailored specifically to each of said human users. In addition, the apparatus can control access to the Internet via integrated web browser software and thus provide protection, especially for young children, from inappropriate web site content.

Other objects and advantages will be readily apparent to those of ordinary skill in the art upon viewing the drawings and reading the detailed description hereafter.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a block diagram of an aspect of the present invention for integrating a fingerprint sensor with an animated and articulated toy.

FIG. **2** shows in functional block diagram a representation of minutiae analysis of the present invention.

FIG. **3** shows in functional block diagram a representation of a neural network of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, an apparatus for an articulated and animated toy capable of recognizing human users **150** and interacting therewith of the present invention is generally referred to by the numeral **100**. Referring now particularly to FIG. **1**, the apparatus **100** includes a computer **113** having a central processor (CP) **116** such as is well known in the art and commercially available under the trademarks Intel® **486** or Pentium®, conventional non-volatile Random Access Memory (RAM) **114**, conventional Read Only Memory (ROM) **115**, conventional disk storage device **118**, and a sound card **117** such as is commercially available under the trademark SoundBlaster™. Computer **113** can be of a standard PC configuration such as is commercially available under the trademarks Compaq® or Dell®, or can be miniaturized and embedded directly in the toy **127** itself. Computer **113** is further operably associated with interface electronics **119** and fingerprint sensor **120**. The fingerprint sensor **120**, mounted inside the toy **127**, such as a plush teddy bear, doll or sophisticated animated and articulated toy, can be one of many devices well known in the art and available commercially under the trademarks Digital Persona U.areU™, Veridicom OpenTouch™, Thomson FingerChip™, and AuthenTec FingerLoc™. The interface electronics **119** can be one of many off-the-shelf units well known by anyone of ordinary skill in the art and commonly employed in personal computers for the acquisition of digital signals such as a standard RS-232 serial port or Universal Serial Bus (USB). The fingerprint sensor **120** described herein above, can be mounted in the head, belly, back, hand, arm, leg or foot of toy **127**, thus providing a simple means by which a human user **150**, such as a child, can access and operate the toy's biometric component.

The computer **113** further has operably associated therewith fingerprint verification software **140** which compares a first digitized human fingerprint **151**, stored on said disk storage device **118** with a second digitized human fingerprint **152** acquired in real-time from human user **150** and provides a signal indicative of verification or non-verification of human user **150**. The fingerprint verification software **140** can be of one of several algorithms known by anyone who is of ordinary skill in the art such as minutiae analysis **200** or neural network **300** or another equivalent algorithm, the particulars of which are further described hereinafter.

A communications cable **121** is likewise associated with the computer **113** and operably connected to interface electronics **119** for providing speech and articulation control signals to interface electronics **119**. If computer **113** is configured as a standard PC, the communications cable **121** will be external, while if computer **113** is embedded directly in the toy **127**, the communications cable **121** will be internal.

Interface electronics **119** is operably connected to the toy's **127** internal control circuits **128**. The control circuit **128** is of a standard type such as is well known to anyone of ordinary skill in the art and employed in several of the toys described in detail herein above, and controls the basic functions of the toy's **127** articulation, including the animation thereof. Control circuit **128** is operably connected to a battery **129** and electronic servo motors **130**. Servo motors **130** are flexibly coupled to mechanical articulating means **131**. Servo motors **130** are arranged in such a way as to cause animation of various features of the toy **127** such as mouth, eye and ear movements.

In addition to the control functions, audio amplifier **124** speaker **125**, and microphone **126** are also operatively connected to sound card **117** which allows the toy **127** to recognize speech, and speak to the human user as part of its interaction capability.

The apparatus of the present invention **100** can make use of minutiae analysis **200**, neural networks **300** or another equivalent software algorithm to generate an output signal indicative of verification or non-verification of a human user **150**.

There are a variety of methods by which the identification and verification element of the present invention can be implemented. Although the methods differ in computational structure, it is widely accepted that they are functionally equivalent. An example of two practical techniques, minutiae analysis **200** and neural network **300**, each successfully implemented by applicant, are provided herein below and are depicted in FIG. **2** and FIG. **3** respectively.

As shown in FIG. **2**, the minutiae analysis **200**, appropriate for implementation of the present invention includes the steps of minutiae detection **210**, minutiae extraction **220** and minutia matching **230**. First, the fingerprint sensor **120** described in detail hereinabove, digitizes template fingerprint **151** (stored in disk storage device **118** during the enrollment process described further herein below) and target fingerprint **152** from human user **150** and generates local ridge characteristics **211**. The two most prominent local ridge characteristics **211**, called minutiae, are ridge ending **212** and ridge bifurcation **213**. Additional minutiae suitable for inclusion in minutiae analysis **200** of the present invention exist such as "short ridge", "enclosure", and "dot" and may also be utilized by the present invention. A ridge ending **212** is defined as the point where a ridge ends abruptly. A ridge bifurcation **213** is defined as the point where a ridge forks or diverges into branch ridges. A fingerprint **151**, **152** typically contains about **75** to **125** minutiae. The next step in minutiae analysis **200** of the present invention involves identifying and storing the location of the minutiae **212**, **213** utilizing a minutiae cataloging algorithm **214**. In minutiae cataloging **214**, the local ridge characteristics from step **211** undergo an orientation field estimation **215** in which the orientation field of the input local ridge characteristics **211** acquired by fingerprint sensor **120** are estimated and a region of interest **216** is identified. At this time, individual minutiae **212**, **213** are located, and an X and Y coordinate vector representing the position of minutiae **212**, **213** in two dimensional space as well as an orientation angle **0** is identified for template minutiae **217** and target minutiae **218**. Each are stored **219** in random access memory (RAM) **114**.

Next, minutiae extraction **220** is performed for each detected minutiae previously stored in step **219** above. Each of the stored minutiae **219** are analyzed by a minutiae identification algorithm **221** to determine if the detected minutiae **219** are one of a ridge ending **212** or ridge bifurcation **213**. The matching-pattern vectors which are used for alignment in the minutiae matching **230** step, are represented as two-dimensional discrete signals which are normalized by the average inter-ridge distance. A matching-pattern generator **222** is employed to produce standardized vector patterns for comparison. The net result of the matching-pattern generator **222** are minutiae matching patterns **223** and **224**. With respect to providing verification of a fingerprint as required by the present invention, minutiae template pattern **223** is produced for the enrolled fingerprint **151** of human user **150** and minutiae target pattern **224** is produced for the real-time fingerprint **152** of human user **150**.

Subsequent minutiae extraction **220**, the minutiae matching **230** algorithm determines whether or not two minutiae matching patterns **223, 224** are from the same finger of said human user **150**. A similarity metric between two minutiae matching patterns **223, 224** is defined and a thresholding **238** on the similarity value is performed. By representing minutiae matching patterns **223, 224** as two-dimensional "elastic" point patterns, the minutiae matching **230** may be accomplished by "elastic" point pattern matching, as is understood by anyone of ordinary skill in the art, as long as it can automatically establish minutiae correspondences in the presence of translation, rotation and deformations, and detect spurious minutiae and missing minutiae. An alignment-based "elastic" vector matching algorithm **231** which is capable of finding the correspondences between minutiae without resorting to an exhaustive search is utilized to compare minutiae template pattern **223**, with minutiae target pattern **224**. The alignment-based "elastic" matching algorithm **231** decomposes the minutiae matching into three stages: (1) An alignment stage **232**, where transformations such as translation, rotation and scaling between a template pattern **223** and target pattern **224** are estimated and the target pattern **224** is aligned with the template pattern **223** according to the estimated parameters; (2) A conversion stage **233**, where both the template pattern **223** and the target pattern **224** are converted to vectors **234** and **235** respectively in the polar coordinate system; and (3) An "elastic" vector matching algorithm **236** is utilized to match the resulting vectors **234, 235** wherein the normalized number of corresponding minutiae pairs **237** is reported. Upon completion of the alignment-based "elastic" matching **231**, a thresholding **238** is thereafter accomplished. In the event the number of corresponding minutiae pairs **237** is less than the threshold **238**, a signal indicative of non-verification is generated by computer **113**. Conversely, in the event the number of corresponding minutiae pairs **237** is greater than the threshold **238**, a signal indicative of verification is generated by computer **113**. Either signal can be utilized to produce a control signal which is communicated by computer **113** to interface electronics **119** via communication cable **121** as described in detail herein above.

Referring now particularly to FIG. **3**, and according to a second preferred embodiment, an exemplary neural network **300** of the present invention includes at least one layer of trained neuron-like units, and preferably at least three layers. The neural network **300** includes input layer **370**, hidden layer **372**, and output layer **374**. Each of the input layer **370**, hidden layer **372**, and output layer **374** include a plurality of trained neuron-like units **376, 378** and **380**, respectively.

Neuron-like units **376** can be in the form of software or hardware. The neuron-like units **376** of the input layer **370** include a receiving channel for receiving digitized human fingerprint data **152**, and stored comparison fingerprint data **151** wherein the receiving channel includes a predetermined modulator **375** for modulating the signal. The neuron-like units **378** of the hidden layer **372** are individually receptively connected to each of the units **376** of the input layer **370**. Each connection includes a predetermined modulator **377** for modulating each connection between the input layer **370** and the hidden layer **372**.

The neuron-like units **380** of the output layer **374** are individually receptively connected to each of the units **378** of the hidden layer **372**. Each connection includes a predetermined modulator **379** for modulating each connection between the hidden layer **372** and the output layer **374**. Each unit **380** of said output layer **374** includes an outgoing channel for transmitting the output signal.

Each neuron-like unit **376, 378, 380** includes a dendrite-like unit **360**, and is preferably several, for receiving incoming signals. Each dendrite-like unit **360** includes a particular modulator **375, 377, 379** which modulates the amount of weight which is to be given to the particular characteristic sensed as described below. In the dendrite-like unit **360**, the modulator **375, 377, 379** modulates the incoming signal and subsequently transmits a modified signal **362**. For software, the dendrite-like unit **360** comprises an input variable $X_a$ and a weight value $W_a$ wherein the connection strength is modified by multiplying the variables together. For hardware, the dendrite-like unit **360** can be a wire, optical or electrical transducer having a chemically, optically or electrically modified resistor therein.

Each neuron-like unit **376, 378, 380** includes a soma-like unit **363** which has a threshold barrier defined therein for the particular characteristic sensed. When the soma-like unit **363** receives the modified signal **362**, this signal must overcome the threshold barrier whereupon a resulting signal is formed. The soma-like unit **363** combines all resulting signals **362** and equates the combination to an output signal **364** indicative of one of a recognition or non-recognition of a human user **150**.

For software, the soma-like unit **363** is represented by the sum $\alpha=\Sigma_a X_a W_a-\beta$, where $\beta$ is the threshold barrier. This sum is employed in a Nonlinear Transfer Function (NTF) as defined below. For hardware, the soma-like unit **363** includes a wire having a resistor; the wires terminating in a common point which feeds into an operational amplifier having a nonlinear component which can be a semiconductor, diode, or transistor.

The neuron-like unit **376, 378, 380** includes an axon-like unit **365** through which the output signal travels, and also includes at least one bouton-like unit **366**, and preferably several, which receive the output signal from the axon-like unit **365**. Bouton/dendrite linkages connect the input layer **370** to the hidden layer **372** and the hidden layer **372** to the output layer **374**. For software, the axon-like unit **365** is a variable which is set equal to the value obtained through the NTF and the bouton-like unit **366** is a function which assigns such value to a dendrite-like unit **360** of the adjacent layer. For hardware, the axon-like unit **365** and bouton-like unit **366** can be a wire, an optical or electrical transmitter.

The modulators **375, 377, 379** which interconnect each of the layers of neurons **370, 372, 374** to their respective inputs determines the classification paradigm to be employed by the neural network **300**. Digitized human fingerprint data **152**, and stored comparison fingerprint data **151** are provided as discrete inputs to the neural network and the neural network then compares and generates an output signal in response thereto which is one of recognition or non-recognition of the human user **150**.

It is not exactly understood what weight is to be given to characteristics which are modified by the modulators of the neural network, as these modulators are derived through a training process defined below.

The training process is the initial process which the neural network must undergo in order to obtain and assign appropriate weight values for each modulator. Initially, the modulators **375**, **377**, **379** and the threshold barrier are assigned small random non-zero values. The modulators can each be assigned the same value but the neural network's learning rate is best maximized if random values are chosen. Digital human fingerprint data **151** and stored comparison fingerprint data **152** are fed in parallel into the dendrite-like units of the input layer (one dendrite connecting to each pixel in fingerprint data **151** and **152**) and the output observed.

The Nonlinear Transfer Function (NTF) employs a in the following equation to arrive at the output:

$$NTF=1/[1+e^{-\alpha}]$$

For example, in order to determine the amount weight to be given to each modulator for any given human fingerprint, the NTF is employed as follows:

If the NTF approaches 1, the soma-like unit produces an output signal indicating recognition. If the NTF approaches **0**, the soma-like unit produces an output signal indicating non-recognition.

If the output signal clearly conflicts with the known empirical output signal, an error occurs. The weight values of each modulator are adjusted using the following formulas so that the input data produces the desired empirical output signal.

For the output layer:

$$W^*_{kol}=W_{kol}+GE_kZ_{kos}$$

$W^*_{kol}$=new weight value for neuron-like unit k of the outer layer.

$W_{kol}$=current weight value for neuron-like unit k of the outer layer.

G=gain factor

$Z_{kos}$=actual output signal of neuron-like unit k of output layer.

$D_{kos}$=desired output signal of neuron-like unit k of output layer.

$E_k=Z_{kos}(1-Z_{kos})(D_{kos}-Z_{kos})$, (this is an error term corresponding to neuron-like unit k of outer layer).

For the hidden layer:

$$W^*_{jhl}=W_{jhl}+GE_jY_{jos}$$

$W_{jhl}$=new weight value for neuron-like unit j of the hidden layer.

$W^*_{jhl}$=current weight value for neuron-like unit j of the hidden layer.

G=gain factor

$Y_{jos}$=actual output signal of neuron-like unit j of hidden layer.

$E_j=Y_{jos}(1-Y_{jos})\Sigma_k(E_k{}^*W_{kol})$, (this is an error term corresponding to neuron-like unit j of hidden layer over all k units).

For the input layer:

$$W^*_{iil}=W_{iil}+GE_iX_{ios}$$

$W^*_{iil}$=new weight value for neuron-like unit I of input layer.

$W_{iil}$=current weight value for neuron-like unit I of input layer.

G=gain factor

$X_i$=actual output signal of neuron-like unit I of input layer.

$E_i=X_{ios}(1-X_{ios})\Sigma_j(E_j{}^*W_{jhl})$, (this is an error term corresponding to neuron-like unit i of input layer over all j units).

The training process consists of entering new (or the same) exemplar data into neural network **300** and observing the output signal with respect to a known empirical output signal. If the output is in error with what the known empirical output signal should be, the weights are adjusted in the manner described above. This iterative process is repeated until the output signals are substantially in accordance with the desired (empirical) output signal, then the weight of the modulators are fixed.

Upon fixing the weights of the modulators, predetermined fingerprint-space memory indicative of recognition and non-recognition are established. The neural network **300** is then trained and can make generalized comparisons of human fingerprint input data by projecting said input data into fingerprint-space memory which most closely corresponds to that data. It is important to note that the neural network **300** described herein above is sensitive to scale, rotation and translation of the input fingerprint patterns. Therefore, preprocessing steps such as those described in detail herein above as employed by minutiae analysis **200** of the present invention should be utilized prior to presenting the fingerprint patterns to the neural network **300**.

The description provided for neural network **300** as utilized in the present invention **100** is but one technique by which a neural network algorithm can be employed. It will be readily apparent to those who are of ordinary skill in the art that numerous neural network paradigms including multiple (sub-optimized) networks as well as numerous training techniques can be employed to obtain equivalent results to the method as described herein above.

The preferred method of registering and subsequently identifying a human user **150**, of the present invention **100** begins with the human user **150**, enrolling an authorized fingerprint(s) from one or more fingers to be utilized as a template(s) for all subsequent verifications. To accomplish this, the human user **150** enters personal information such as name, nickname, age, sex, and an optional PIN number for example, into computer **113** whereupon said information is stored in a user file on fixed disk **118** and in so doing initiates the enrollment process. The computer **113** subsequently acquires several digitized first human fingerprints of the human user **150** through the use of fingerprint sensor **120** embedded in toy **127**. These first human fingerprints are processed, the highest quality fingerprint(s) selected and thenceforth encoded and stored in the fixed disk **118** of computer **113**. This remaining first human fingerprint will be utilized thereafter as an authorized template fingerprint(s) **151**. The above described process can be repeated if the user wishes to enroll additional fingerprints from other fingers on the user's hand. Typically, for this application four template fingerprints **151** are sufficient for reliable recognition of human user **150**. In addition, other human users, such as family members and friends, can be enrolled by utilizing a process similar to that described for human user **150** herein above.

With respect to Internet access control of the present invention **100**, the enrollment process described herein above is utilized for each authorized user **150** and is further controlled by a system administrator who is also an authorized human user **150**. The system administrator would be responsible for providing additional information for each user pertaining to the Internet web sites each of said authorized human users **150** would be allowed to visit. In this way, the administrator, which could be a parent or guardian, can individually control what Internet access is granted for each of said other human users **150**. The toy **127**, upon recognizing each individual human user, would only permit the user to visit the web sites which were previously identified by the system administrator. Each of said human users **150** would be unable to change which sites could be visited without the permission of the system administrator.

Once the human user(s) **150** have been enrolled as described in detail herein above, the toy **127** enters the identification mode wherein it is capable of recognizing a human user **150**. There are myriad applications for toy **127**, which can make use of the capability of recognizing a human user **150**. These applications include various games, educational and interactive software, and the ability to protect users, and more particularly children, from inappropriate Internet web site content. In addition, the toy could provide biometric security for Internet access including protecting the privacy of electronic correspondence (email).

When a human user **150** selects a program stored in computer **113** for interacting with the toy **127**, the human user **150** will be instructed to touch the fingerprint sensor **120** embedded in toy **127** and thus triggering a verification event. Once human user **150** touches fingerprint sensor **120** with one of the fingers or thumb previously enrolled as described in detail herein above, fingerprint sensor **120** begins acquiring second human fingerprints of the human user **150** and converts said second human fingerprints to digital data which is subsequently transmitted to computer **113** via interface electronics **119**. The digitized second human fingerprint(s) obtained thereafter are stored in the nonvolatile RAM memory **114** of computer **113** as target fingerprint(s) **152**.

Once the said target fingerprint(s) **152** has been stored in the computer **113**, the verification software **140**, either minutiae analysis **200** or neural network **300**, or another **110** suitable algorithm is employed to perform a comparison between said stored template fingerprint(s) **151** and said stored target fingerprint(s) **152** and produce an output signal in response thereto indicative of recognition or non-recognition of the human user **150**. The output signal is subsequently utilized by the software to generate a control signal which can include animation and articulation control for toy **127**. The control signal is therewith provided to the interface electronics **119** via communications cable **121**. Interface electronics **119** is additionally responsible for interfacing the computer **113** with toy's **127** control electronics **128** and enabling the transfer of signals thereto. In the event the said target fingerprint(s) **152** of human user **150** is recognized, the software can be designed to provide a variety of control signals to toy **127**, or can utilize the recognition signal internally as would be the case in controlling Internet web site access. In the event the said target fingerprint(s) **152** of human user **150** is not recognized, the software can be disabled thus preventing access to the program, game or Internet by an unrecognized and unauthorized human user. In addition, in the event target fingerprint(s) **152** of human user **150** is not recognized, the apparatus **100** can optionally notify an authorized system administrator in the event the non-recognition signal is erroneous and a product of a software fault.

The above described embodiments are set forth by way of example and are not for the purpose of limiting the claims of the present invention. It will be readily apparent to those or ordinary skill in the art that obvious modifications, derivations and variations can be made to the embodiments without departing from the scope of the invention. For example, the fingerprint verification engine described above as either minutiae analysis or neural network could also be one of a statistical based system, template or pattern matching, or even rudimentary feature matching. Accordingly, the claims appended hereto should be read in their full scope including any such modifications, derivations and variations.

What is claimed is:

**1**. An interactive entertainment apparatus comprising:

a teddy bear capable of providing entertaining interaction with multiple human users;

a fingerprint capture device mounted within the abdomen of said teddy bear in a position to enable access by said human users, said fingerprint capture device being adapted to acquire a representation of a fingerprint of one of said human users, and said acquisition device being adapted to produce a signal relative to the acquired representation; and

a processor associated with said acquisition device in a manner to receive the produced signal from said acquisition device, said processor being adapted to compare the produced signal relative to data stored in memory and to provide an output signal indicative of recognition;

wherein the entertainment device provides said entertaining interaction in response to said output signal indicative of recognition.

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